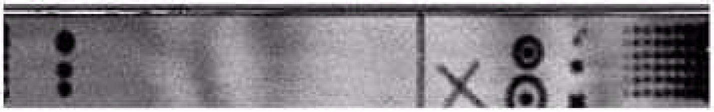
Scanning Ultrasonic Spectroscopy System Developed for the Inspection of Composite Flywheels

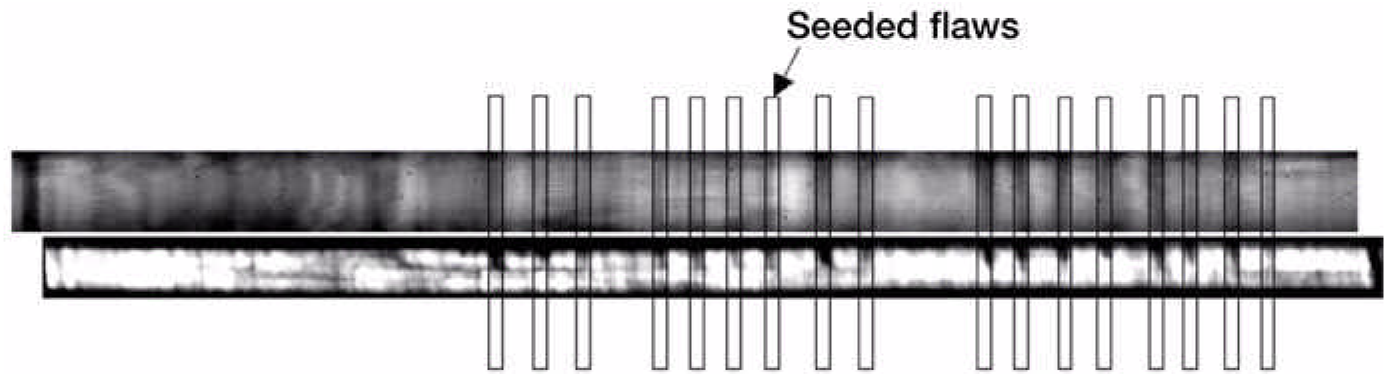
Composite flywheels are being considered as replacements for chemical batteries aboard the International Space Station. A flywheel stores energy in a spinning mass that can turn a generator to meet power demands. Because of the high rotational speeds of the spinning mass, extensive testing of the flywheel system must be performed prior to flight certification. With this goal in mind, a new scanning system has been developed at the NASA Glenn Research Center for the nondestructive inspection of composite flywheels and flywheel subcomponents. The system uses ultrasonic waves to excite a material and examines the response to detect and locate flaws and material variations.

The ultrasonic spectroscopy system uses a transducer to send swept-frequency ultrasonic waves into a test material and then receives the returning signal with a second transducer. The received signal is then analyzed in the frequency domain using a fast Fourier transform. A second fast Fourier transform is performed to examine the spacing of the peaks in the frequency domain. The spacing of the peaks is related to the standing wave resonances that are present in the material because of the constructive and destructive interferences of the waves in the full material thickness as well as in individual layers within the material. Material variations and flaws are then identified by changes in the amplitudes and positions of the peaks in both the frequency and resonance spacing domains. This work, conducted under a grant through the Cleveland State University, extends the capabilities of an existing point-by-point ultrasonic spectroscopy system, thus allowing full-field automated inspection.



Results of an ultrasonic spectroscopy scan of a plastic cylinder with intentionally seeded flaws.

Shown in the preceding figure is the result of an ultrasonic spectroscopy scan of a plastic cylinder used as a proof-of-concept specimen. The cylinder contains a number of flat-bottomed holes of various sizes and shapes. The scanning system was able to successfully detect all the defects in the material. Ultrasonic spectroscopy results for a second specimen are shown in the following figure along with a conventional ultrasonic C-scan. The second specimen is a section of a flywheel subcomponent that has a series of drilled holes and notches. This specimen is employed as a defect detection standard to evaluate the various nondestructive evaluation methods under consideration. Scanning results demonstrate the ability of the system to detect flaws on the order of 10 mils in the radial direction and 5 mils in the circumferential direction.



Scanning results for a nondestructive evaluation standard specimen. Top: Ultrasonic spectroscopy results. Bottom: Standard ultrasonic C-scan. Flaw locations are highlighted by boxed areas.

Work conducted to date has shown that scanning ultrasonic spectroscopy is a viable tool for the inspection of composite flywheel systems. Ongoing development work is focused on refining the system and scanning parameters for improved resolution and defect detection.

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